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# MANUFACTURING LEAD TIME REDUCTION IN A SCAFFOLD MAKING INDUSTRY USING LEAN MANUFACTURING TECHNIQUES – A CASE STUDY

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**ABSTRACT**

*The lean manufacturing techniques are used to improve the industrial benefits by reducing the wastages. Wastages mean the non-value adding processes or works. This study focus on how lean manufacturing techniques are used to reduce the manufacturing lead time of a scaffold manufacturing company. To obtain this, there is a wide variety of lean manufacturing techniques used, such as value stream mapping, 5S housekeeping tool, SMED and kaizen. Even though the main objective is to reduce lead time, there are also other objectives like increase in productivity, increase in quality, improvement in meeting the customer demands, improvement in on-time delivery, improvement in customer satisfaction, and machine utilization with reduction in wastages, inventory, huge material handling, and idle time, down time, setup time, space consumption and labor cost. Instead of investing huge amount in new machines to increase the working efficiency, it is much better to adopt these Lean techniques at this demonetized condition of India.*

**Key words:** 5 S, Lead time, Productivity, Scaffold Manufacturing, SMED.

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## 1. INTRODUCTION

Lean manufacturing is a collective variety of technique which can be used to improve the productivity, quality, improvements in meeting the customer demands, customer satisfaction with the reduction of lead time, huge material handling, cost, labor efforts, by eliminating the wastages that are known as non-value adding activities. In other words, it can be defined as the optimal use of existing resources and increasing value addition. Value addition is nothing but any change that takes place to the material for which the customer is willing to pay such as shape, size, color and purpose of use. During early

twentieth century in Japan, the founder of Toyota Textiles "Sakichi Toyoda" started the lean practices in his textiles by inventing one power loom system. After him his son "kichiriio Toyoda" started the Toyota car industry and came up with the just-in-time concept. So these two steps are considered as the starting pillars of Toyota Production System (TPS), which is later known as the lean manufacturing system. Then the Second World War began. After kichriio his son Eiji Toyoda took charge and he decided to lift the company to international standard. So he employed a supervisor in-charge named Taichii Ohno who became the Father of Toyota Production System. In the year 1988 the TPS got attention of western countries. And they named it as lean manufacturing. Lean manufacturing can be applied in any kind of industries. It is a continuous improvement system. That gives a better environment within the company. Also it helps to improve the working culture of every worker. There are a variety of techniques for lean manufacturing which include: value Stream mapping, JIT, 5S, kaizen, kanban, Single minute Exchange of Die (SMED), poka-yoke, single piece flow, total productive maintenance, cellular manufacturing, visual management and Autonomation. Depending on the troubles or problems any of the tools can applied to improve the system.

## 2. MOTIVATION

The main motivation of this work, it was a government funded project. QCI (Quality council of India) and MSME (Micro Small Medium Enterprise), these two government bodies are involved in this project. Also lean manufacturing is a proven technology in various industries in Japan and abroad. Now Indian industries have commenced the application of lean because of the sustenance power which can be obtained from the techniques there by enabling them to compete with the global market. With the help of value stream mapping, the flow of material can be identified which focuses on the bottle neck area in the production system. Another tool 5S can be implemented in any kind of work stations as a basic tool of lean technique, the improvements is well identified from the industries. The lean techniques are well known and result oriented, the change occurs only in the type of implementation. Because of these the project is a challenging one. From the first look itself the scope of implementation in the scaffold manufacturing company is giving a wide range of improvements. Based on this research, these techniques will provide good improvement in the scaffold manufacturing company.

## 3. LITERATURE REVIEW

Lean in manufacturing focuses on improving the throughput of a facility, reducing the lead time, inventory, defects, rework and process wastes and ultimately improving financial savings and customer satisfaction [1]. Many organizations are enthusiastic to adopt lean manufacturing in order to improve the performance in this competitive market where uncertainty is prevalent [2]. Lean means efficient use of the available resources by cutting the non-value added (NVA) activities [3]. Lean manufacturing is a collection of practices that work together synergistically to create a streamlined, high quality system that produces finished products at the pace of the customer demand [4]. The adoption of lean has enabled the company to focus on timely delivery of quality product to the customer with low waste [5]. The core of Lean is based on the continuous pursuit of improving the processes, a philosophy of eliminating all non-value adding activities and reducing waste within an organization. The Value adding activities are simply only those things the customer is willing to pay for, everything else is waste, and should be eliminated, simplified, reduced, or integrated. There are a number of Lean techniques available such as, Value Stream Mapping, Visual Workplace, Setup Reduction, Cellular/Flow Manufacturing, Pull Systems and Total Productive Maintenance etc [6]. Lean can be summarized in a very short definition that doing more with less [7].

## 4. OBJECTIVE OF WORK

The main objective of this project is to reduce the total lead time of the scaffold manufacturing process. To obtain this there is a wide variety of lean manufacturing techniques to be applied. That is value stream mapping, 5S housekeeping tool, SMED, Autonomation, kaizen, Autonomous maintenance, Kanban system. This project is a government funded project. Mainly four stakeholders are there which include QCI (Quality council of India), MSME (Micro Small Medium Enterprise), Sreerama scaffold system pvt.ltd, Palakkad and Troika Learning Solutions pvt. Ltd., Bangalore. Even though the main objective is to reduce lead time, there is other objective also increase productivity, increase quality, improvement in meeting the customer demands, improvement in on time delivery, improvement in customer satisfaction, machine utilization with reduction in wastages, inventory, huge material handling, idle time, down time, setup time, space consumption, labor cost. These are the fundamental objectives. Also the stakeholder's satisfaction is a major objective because in each stage there is an audit from the side of both QCI and MSME. And as a part of 5S a standard work format will be created. So that any future improvement can continues from that point.

## 5. CASE STUDY

Sreerama Scaffolding Systems Pvt. Ltd. is a manufacturing company pioneer in the field of scaffolding manufacturing. They manufacture construction equipments such as props, spans, scaffoldings which are used to provide support for the beams and slabs from ground. So in order to obtain improvements in this company lean manufacturing was adopted.

### 5.1. Methodology

The methodology of this project is as follows.


**Figure 1** Methodology

The work started based on the literature survey. Then the value stream mapping conducted that was necessary. An efficient method of research design was adopted for this project. Several interview session conducted together with observation has been done to collect data related to this study. The interviewed session were conducted with managing Director, managers from production department, supervisor and workers.

# 6. TOOLS REQUIRED

## 6.1. Value Stream Mapping

Value stream mapping is a technique used in lean manufacturing to analyze the material flow from supplier to customer through different processes. Also includes the total time required for the conversion of raw material to finished good for a particular item. So, it was chosen as prop. It has mainly two parts that is inner part and outer part. It indicates the total time of raw material held inside company. By analyzing the current state can propose the future state of the product.

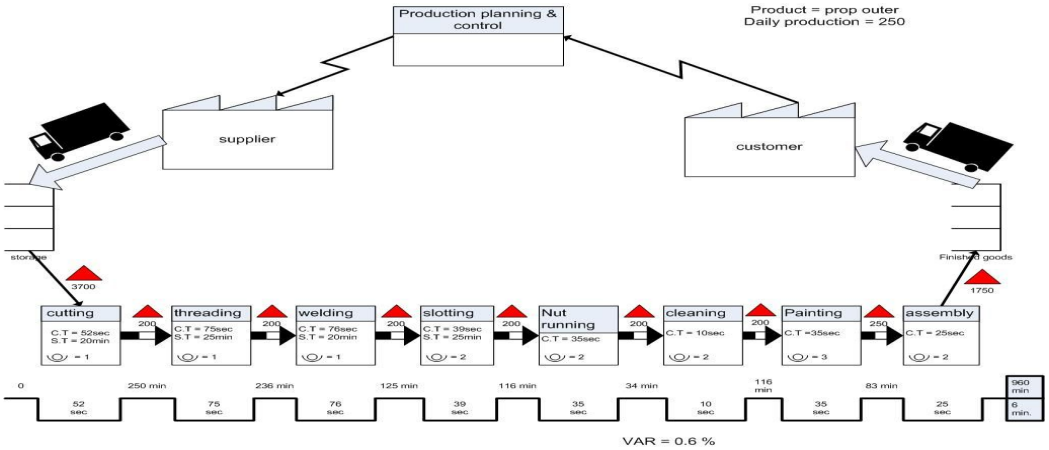



**Figure 2** Current State - Prop outer part

In the current state value stream mapping, the material flow is shown from the supplier to customer through different manufacturing processes. Firstly raw material is moved from store to cutting process for the cutting operation for one piece which is around 52 seconds including loading and unloading, which can be referred to as the cycle time. Then next operation is thread running, there a high level of inventory can be seen. This is because of the mass production; also it was barely stacked on the floor. Always there will be more than 250 prop item held. Similarly for the other process also, that is around 1500 item are held between these stages. While calculating the total lead time it is coming as 960 minutes. When the case of cycle time for one piece to complete is just 6 minutes. From this calculation the value added ratio is gotten by dividing cycle time with lead time and multiplied by 100. So here it comes around 0.6%. This 0.6% is the total value added ratio. From this it is a well known fact that the other time are occurring because of the wastes. So the main objective is to increase the value added ratio of these products.

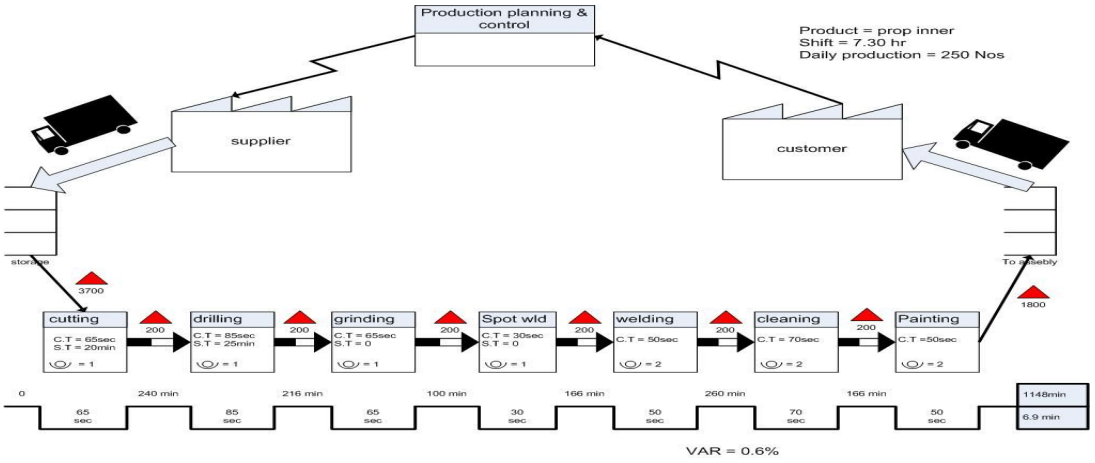



**Figure 3** Current State – prop inner

This is for the prop inner product, here also the similar process and same kind of wastages with high inventory in all stages. So in order to obtain one scaffold product this prop outer and prop inner needed to be assembled. Here also the value added ratio is only 0.6 %.

By using these details and analysis with the observed data along with the interview details a future state of two sessions proposed as follows.

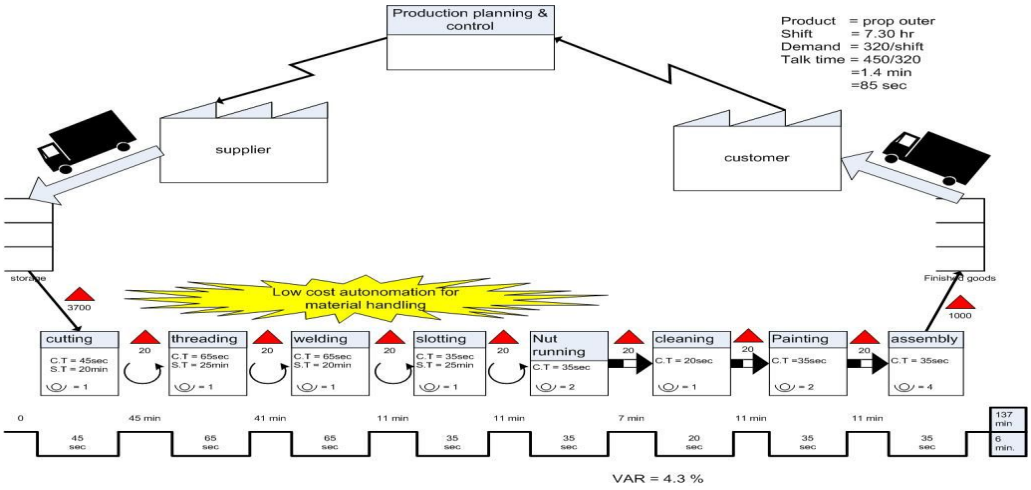



**Figure 4** Future state

Because of the lean principles mass production is not at all encouraged so batch size is reduced to twenty. The batch size is fixed as twenty because of the threading process. After threading there must be high temperature on the threaded area. And also there is some oil consumption inside prop, it needed to remove. In order to neglect these two issues some time required between the processes, which is neither more nor less. So it was best to fix batch size as twenty. So that the inventory level can be reduce from 200 to 20. Also, instead of the push system, some of the processes or work stations can be improved as a manual pull system, thereby creating a minor just in time culture in the company. By reducing the batch size the total lead time for one piece should reduce. This will increase the value added ratio. The wastages will reduce drastically.

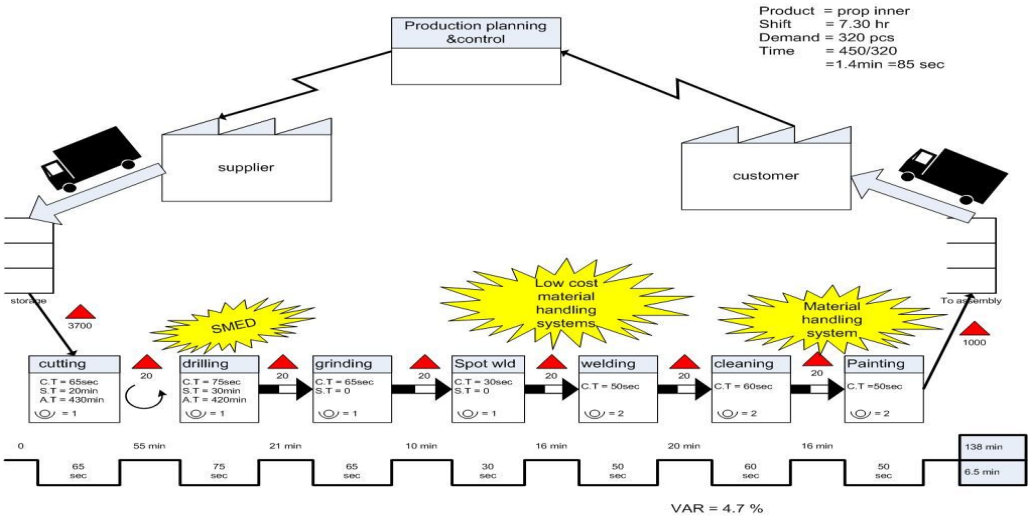



**Figure 5** Future state

Also in certain areas some material handling systems are placed, it made both the motion of material and workers as easy as possible. Tiredness is eliminated and got savings in time. This is similar in both cases of prop outer and prop inner.

The major advantage of this proposed future state is that by applying these techniques the product will reach on the customer after 138 min. instead of 1148 min.

## 6.2. 5S House keeping

The 5S housekeeping is a tool which is widely used as a starting tool of lean implementation. The main advantage of 5S housekeeping is that it helps to identify the hidden problems. As similar to lean philosophy this also originated in Japan. This technique is used to improve the work stations. Also it helps to improve the working culture. So each step in the 5S is equally important.

Sort : Sorting is first and important step, in which the unwanted items/materials are removed from the work stations.

Set in order : As the name implicates every item which is necessary in the work station are needed to be placed properly with particular place.

Shine : It means cleaning, after set in order cleaning is necessary

Standardize : Every action/process should be documented up to the present stage. So only further improvements can be started from that point.

Sustain : The final step is sustenance, through this only the 5S will fully applied in an industry. Actually this step can be called an appreciation stage


**Figure 6** Machine layout


**Figure 7** Store


**Figure 8** Production Area


**Figure 9** Guide ways & Yellow markings

| BEFORE | AFTER |
|---|---|
|  |  |

**Figure 10** Floor

| BEFORE | AFTER |
|---|---|
|  |  |

**Figure 11** Pathway

## 6.3. Kaizen

Kaizen is also a Japanese word which means continuous improvement. Through kaizen only the company can improve in any process or workstation improvements. Kaizen can be defined as any improvement which eases the works. Any small improvement can be considered as a kaizen. The entire Toyota production system / lean manufacturing can be referred to as kaizens, because everything is continuous improvement. it is the most important tool and plays the vital role from the worker's side, as they are the actual producer of kaizen. And the other main advantage any one can contribute to kaizen like CEO, managers, supervisors and workers.

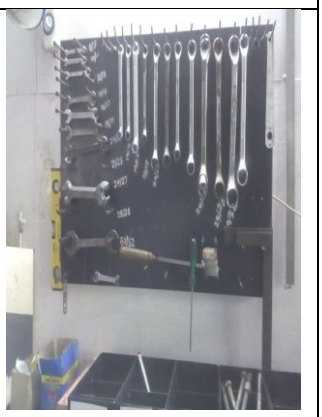
| A tray like structure is made using steel net to prevent the chips falling while performing drilling operation with the drilling machine. | The finished goods are arranged in a proper way to reduce the usage of floor space. | Guide ways are created for the movement of WIP using gravity at the inner welding section. | Tool board in the store |
|---|---|---|---|
|  |  |  |  |

**Figure 12**

| New trolley is made for carrying the scaffolds | Base plates are stacked properly | New cupboard is placed to keep the necessary tools. | Another type of trolley to carry the material and around the floor |
|---|---|---|---|
|  |  |  |  |

**Figure 13**

## 6.4. SMED

Single minute exchange of die is another major technique widely used in manufacturing industries. This is mainly based on the setup time reduction. Industries are facing a major issue of unavailability of machine for effective works, in most of the cases this occur as a result of setup time of either tool or die. So in order to reduce this setup time, SMED techniques are applied. In SMED mainly two types of activities are classified such as internal and external activities. Internal activity means, the activity which can be done only by turning off the machine. Whereas, the actions can be execute while the machine performing in the case of external activities. So as the first step of SMED, critical activity's set up time identified, and then took the actual time for the setup of tools or dies, setup cost calculation along with time. After that differentiates the internal and external activities based on the current way of execution. Then identify the activities which can convert from internal to external activity. Also data collection before and after SMED is necessary, then analyzes the results. This is the format for the SMED implementation.

**Table 1** Critical Activities category conversion

| Sl. No | Activities | Category | Category changed | Technique used | Machine |
|---|---|---|---|---|---|
| 1 | Cleaning of scraps | Internal | Internal | A tray like structure is made to collect scraps which attached to the machine it can easily remove. |  |
| 2 | Sharpening of drill bits | Internal | External | Before starting the work the drill bits are sharpened, also one extra drill bit set (13 bits) provided. | |
| 3 | Loading & unloading of pipe | External | External | A guide way created for the easy movement of pipes so that worker need not move from the machine side. | |
| 4 | Searching for tools | Internal | External | A new tool board is placed near drilling machine, so the easy retrieval is done. | |

SMED plays a vital role in improving the performance of manufacturing industry. High setup time may lead to less production rate and less productivity.

# 7. RESULT ANALYSIS

## 7.1. Value Stream Mapping

With the help of value stream mapping the manpower required in each work station is identified. Also the time calculation for each process identified. So from some of the work stations the number of workers is reduced and at the same time in some other work stations the number of workers increased. One person each took out from slotting, cleaning and painting sessions and shifted two persons in the assembly area. It will increase the working efficiency. Now there is one extra worker is there, he can possibly work in night shift.

**Table 2** Optimal Manpower Requirement

| Manpower | | |
|---|---|---|
| **Work station** | **No. of operators Before** | **No. of operators After** |
| cutting - prop outer | 1 | 1 |
| threading - prop outer | 1 | 1 |
| welding - prop outer | 1 | 1 |
| slotting - prop outer | 2 | 1 |
| nut running - prop outer | 2 | 2 |
| cleaning - prop outer | 2 | 1 |
| painting- prop outer | 3 | 2 |
| cutting - prop inner | 1 | 1 |
| drilling -prop inner | 1 | 1 |
| grinding - prop inner | 1 | 1 |
| spot welding - prop inner | 1 | 1 |
| welding - prop inner | 2 | 2 |
| cleaning - prop inner | 2 | 2 |
| painting - prop inner | 2 | 2 |
| material handling | 4 | 4 |
| Assembly | 2 | 4 |
| total | 28 | 27 |

## 7.2. 5S Housekeeping

**Table 3** Benefit Due to Scrap Removal

| SCRAP REMOVAL | | | |
|---|---|---|---|
| **ITEM** | **KG** | **PRICE/KG** | **SAVINGS** |
| PIPE | 1000 | 16 | 16000 |
| Next 11 months 10% of scrap removal must be there | | | 17600 |
| TOTAL | | | 33600 |
| ANNULAISED SAVINGS | | | 33600 |

**Table 4** Benefit Due to Searching Time Reduction

| SEARCHING TIME | | | | | | |
|---|---|---|---|---|---|---|
| **ITEM** | **BEFORE(MIN)** | **AFTER (MIN)** | **FREQUNCY** | **SAVED** | **LABOUR COST PER MIN** | **SAVINGS** |
| TAPE | 5 | 0.2 | 1 | 4.8 | 0.80 | 100 |
| ALLEN KEYS | 6 | 0.3 | 1 | 5.7 | 0.80 | 118.8 |
| SPANNER | 5 | 0.2 | 1 | 4.8 | 0.80 | 100 |
| NUTS N BOLTS | 10 | 1 | 2 | 18 | 0.80 | 375 |
| TOTAL | | | | | | 693.8 |
| ANNUALISED SAVINGS | | | | | | 8325 |

**Table 5** Benefit Due to Space Savings

| SPACE SAVINGS | | | |
|---|---|---|---|
| **ZONE** | **SAVED** | **RENT/SQ FT** | **SAVINGS** |
| PRODUCTION 1 | 775 | 2.94 | 2279.41 |
| PRODUCTION 2 | 600 | 2.94 | 1764.71 |
| PAINTING 1 | 350 | 2.94 | 1029.41 |
| ASSEMLY | 530 | 2.94 | 1558.82 |
| PANTING 2 | 320 | 2.94 | 941.176 |
| TOTAL ANNUALISED SAVINGS | | | 7573.53 |
| ANNUALISED SAVINGS | | | 90882.4 |

**Table 6** Total Savings Due to 5S Implementation

| **PROCESS** | **AMOUNT (Rs)** |
|---|---|
| SCRAP REMOVAL | 33600 |
| SEARCHING TIME | 8325 |
| SPACE SAVINGS | 90882.4 |
| TOTAL ANNUALISED SAVINGS | 132807 |

As a part of 5S benefit calculation, mainly there is three types of benefits. They are (1) benefit due to scrap removal, (2) benefit due to reduction in searching time, (3) benefit due to reduction in space consumption. So by selling of the scrap items on an average of 33600/- saved in a year. Likely for the tools or any other materials searching time is reduced. Consider it in value, an amount of 8325/- is saved yearly. Finally the main saving is the space savings, the saved space can be use, efficiently for other plans. So from all the six zones on an approximate value of 2575 square feet area is saved. This must considered in value it will be an amount of 90882 /- in a year. So the total annualized savings due to the 5S housekeeping is 132807 /- rupees.

### 7.3. SMED (Single Minute Exchange of Die)

**Table 8** Time Savings by Applying SMED

| Sl. No | Activities | Before SMED (min) | After SMED (min) | Time Difference (min) |
|---|---|---|---|---|
| 1 | Cleaning of scraps | 10.46 | 3.28 | 7.18 |
| 2 | Sharpening of drill bits | 90.0 | 20.0 | 70.0 |
| 3 | Loading & unloading of pipe | 1.0 | 0.66 | 0.33 |
| 4 | Searching for tools | 6.0 | 1.0 | 5.0 |
| Total time | | 107.46 | 24.94 | 82.52 |

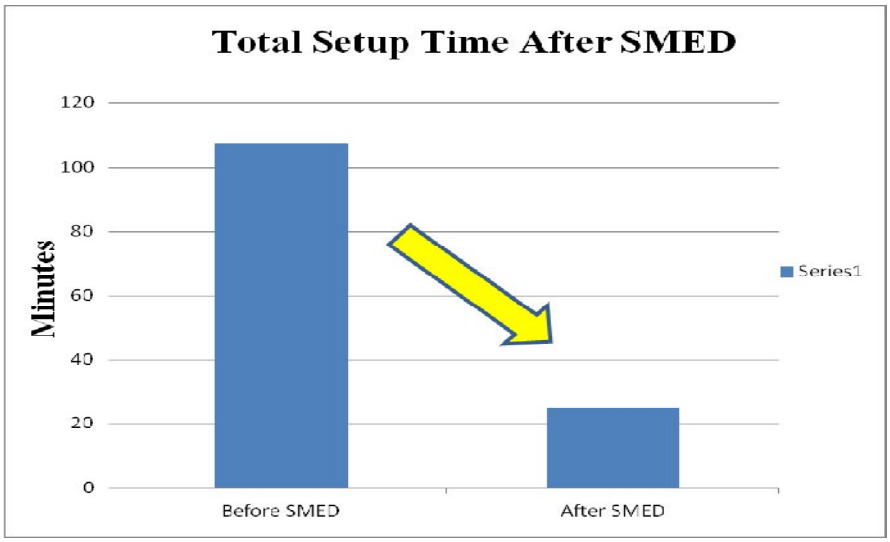



**Figure 14** Setup Time Before and After SMED

SMED plays an important role in the setup time reduction. It was clear before SMED that it took 107.46 minute daily for the setup of one single machine. So while doing the activities in a planned proper manner the total time is reduced from 107.46 min to 24.94 minute. which means that 82.52 minute or nearly one and half hours is saved daily. It will help to increase the productivity. Work in progress (WIP) reduced from 200 pieces to 20 pieces between stations as a result of single piece flow with automated material handling systems using gravity. And as a result of these combined techniques of VSM, 5S and SMED productivity increased from 15 - 20% that is 250 to 320 pieces.

## 8. CONCLUSIONS

The main objective of this project was to reduce manufacturing lead time, for that purpose lean manufacturing techniques were adopted. And it was found very useful in every aspect. Through lean manufacturing, the company's productivity, qualities, machine utilization, on time delivery, customer satisfaction were increased. Also the main objective lead time reduction along with reduction in wastages, inventory, huge material handling, idle time, down time, setup time and space consumption were achieved successfully. Each technique is useful for different kind of problems. Through value stream mapping most of the bottleneck areas identified. And it helped to reduce the manpower in work stations. 5S housekeeping played a very important role to lift the company atmosphere to high standards. Also the working nature and attitude of each worker changed a lot from the past condition.

Everything arranged in a proper way. An overall well oriented industrial look was obtained both in the office and shop floor. By applying SMED the setup time was highly reduced thereby leading to increase in productivity. So lean manufacturing is totally a worthy project. Exactly lean manufacturing is all about doing more with less, and also make improvements by the optimal use of existing resources.

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